

# The perceptions of faculty engaged in a curricular change to Project Based Learning in an Engineering School at Brazil

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## Abstract

The curricular change of an engineering school had as guideline the partial replacement of traditional school activities by Projects and Workshops, which put students as the main protagonists in the learning process, working actively. In this context, faculty were encouraged to propose activities that fulfil this request. Teachers from various specialties and even those who work in more advanced disciplines have submitted their proposals, which were offered to freshman students of an engineering course. The opening of the new curriculum began in 2015 when those activities were introduced in the course. The aim of this study is to know, analyze and evaluate the perception from teachers engaged in create these Projects and Workshops to this new curriculum. The survey was conducted from two focus groups, one with teachers' proponents of Projects and other with teachers' proponents of Workshops. The results show that the teachers attribute different meanings to the goals, strategies, evaluation and their own role in the process, though all the activities aim to ensure a common basis on engineering knowledge, which reflects the inductive character chosen in the curricular change.

**Keywords:** Curricular change, Project Based Learning, Faculty perceptions.

## 1 Introduction

The curriculum change has a life cycle that begins in a formal proposal named "ideal curriculum" chosen and adopted by the school organization. Afterwards, this initial step is translated into manuals and textbooks and became the "formal curriculum" that, in turn, will be translated again on "operational curriculum", which take shape from whom will implement it in the classroom (Goodlad, 1979).

Project Based Learning – PBL, is an alternative to traditional curriculum to promote the training of new engineers, by introducing technological tools and classroom strategies in an interdisciplinary frame, which may develop skills required in the labor market (Mesquita et al, 2013). There are many teachers that start to use these strategies in classroom (Kolmos, 1996; Lima et al, 2012), trying to involve their students, stimulating motivation for learning and assuring the development of new skills (Kolmos and De Graaff, 2007). To support the change to PBL, Powell and Weenk (2003) listed three conditions: Infrastructure - Facilities, training the teaching staff and communication that can ensure a common basis on the perception and need to change; Authority - To ensure the planning, lead and progressive institutionalized implementation, and; Consensus – Among all direct stakeholders involved on innovation process. All of these are important to ensure a good change.

The aim of this work is to analyze the motivation and expectations of teachers involved in the transformation of an "ideal curriculum" into a "formal curriculum". They are responsible for proposing Projects, Workshops and Engineering Practices to compose a list of activities offered to students of the first period of an engineering school in which are promoting a curricular change toward to a PBL curriculum. More precisely, the objective is to identify their perception on process - the evaluation tools, the main characteristics of the projects and workshops offered to students, the relationship of this activities with the disciplines of curriculum; the role of process agents - students and teachers; and the contribution of Projects, Workshops and Engineering Practices of curricular change, the product of this change.

Fernandes et al. (2008) suggest the model Context, Input, Process and Product - CIPP as a tool that links the curriculum to the decision-making process. The authors used these results to interpret the PBL application in the course of Industrial Management, University of Minho. In this model, the context evaluates the needs,

problems and opportunities based on the objectives and significance of the products. The Input evaluates alternative approaches to project planning and resource allocation. The Process evaluates the implementation of plans to guide the activities and later to explain the Product, which in turn, are interpreted as the result of curricular aims.

This work is the third part of a major project of research, which analyzes the full curricular change in the first period of an engineering school. The first work studied the perceptions of teachers on PBL before the announcement of the curricular change (Mattasoglio Neto et al, 2015a). The second analyses the motivation to curricular change, from the head of the managers of school, which started this process (Mattasoglio Neto et al, 2015b). Now, it is time to know the perceptions of teachers involved in delivering proposals of Projects and Workshops, which will be offered in the course.

## 2 Methodology

The main aim of this work is to identify the point of view of teachers who are the proponents of activities, on the process - the evaluation tools, the main characteristics of the projects and workshops offered to students; the process agents, students and teachers' roles; and the product, contribution of Projects, Workshops and Engineering Practices of curricular change. Therefore, methodological approach has bases on two focus groups, one with four teachers' proponents of Workshops (FG1) and another, with four teachers' proponents of Projects or Engineering Practices (FG2).

### 2.1 Context of the study

The Mauá Engineering School - EEM is an engineering school that offers nine engineering courses, with classes from February to December, in an annual calendar. A curricular change is taking place since February 2015, with the main guideline focused on increasing the use of Workshops, Projects and Engineering Practices undertaken by the students at the school, under the supervision of a teacher.

For the first period some Projects, Engineering Practices and Workshops were created by a group of teachers, which asked the management group of School, responsible by the "ideal curriculum". The guidelines for these activities were: should be carried out by students in the school environment; without necessarily having ties to the disciplines of the 1st year of the course; without the need for an evaluation with grading and be carried out with the active participation of students. A call for proposals was opened and teachers of various periods proposed almost 100 works. To this total, 38 were accepted and offered to students who freely chosen those who would hold. Table 1 shows activities offered to students.

Table 1 - Projects, Engineering Practices and Workshops offers to students

Projects - Period of 8 months	Workshops – Period of 4 months	Engineering Practices – Per. 4 months
PRO 101 – Jam Manufacturing	PRO 401 – Mathematical bases	PRO 701 – Fuel injection
PRO 102 – Autonomous robot	PRO 402 – Graphics	PRO 702 – Spaghetti Bridge
PRO 103 – Flying over the campus	PRO 403 – Competitive Brazil	PRO 703 – Aerodynamics of buildings
PRO 104 – Water treatment	PRO 404 – Entering by cone	PRO 704 – Lean production
PRO 105 – Industrial shed	PRO 405 – The Logic of games	PRO 705 – Sustainable City
PRO 106 – Electronic games	PRO 406 – Knowing LINUX	PRO 706 – Chips Fruits
PRO 107 – Soap manufacturing	PRO 407 – The art of solving problems	PRO 707 – "Houston, we have ...
PRO 108 – Weather station	PRO 409 – Modern physics	PRO 708 – Mobile applications
PRO 109 – Waterway	PRO 410 – Creating problems	PRO 709 – Rocket Science
PRO 110 – Skateboards factory	PRO 411 – Negotiation	PRO 711 – Master user
PRO 111 – Combustion engine	PRO 412 – Excel-VBA	PRO 712 – Engineer Stirling
	PRO 413 – Python	PRO 713 – Corrosion
	PRO 415 – Newton in equilibrium	PRO 714 – Tensile/Compression
		PRO 715 – Arduino

Activities were offered in different times, in periods of 2 hours per week, usually after school hours to the 1st period. One student ought to perform in year, at least: A Project, a Workshop, a Practical Engineering and another Workshop or Engineering Practice, that is, on average, the student should meet a minimum total of 5 hours per week of these activities (4 at first half and 6 in other).

## 2.2 Data collection and analysis

This research is an exploratory study, which aims to get prior knowledge from teachers about the Projects, Engineering Practices and Workshops, introduced on new curriculum. This study have as basis two focus groups conducted, both with four participants, one of them with proponents of Projects and Practices of Engineering and other with proponents of Workshops. They were chosen without specific criteria, among about 30 teachers proponents of Projects, Engineering Practices and Workshops. The focus groups had a previous script, characterizing then as a semi-structured interview (Lüdke and André, 1986). Some dimensions addressed in focus group to know the point of view of teachers about Projects, Engineering Practices and Workshops were: Importance in training students; Strategies used to carry out these activities; Learning assessment of students; Role of participants; Difficulties in its implementing. Were held during April 2015, recorded in audio with the consent of the interviewees and transcribed, to allow a precise analysis of its contents (Bardin, 2009). In that analysis respondents were nominated from [FG1Px] or [FG2Py] with x and y from 1 to 4, without a relevant criterion for this numeration. These numbers appear in the analysis and discussion of the results, near of excerpt transcript of the speech to illustrate the results obtained.

## 3 Findings

From the data analysis, emerged four relevant dimensions used to discuss the perception of teachers about the new configuration of curriculum: Learning environment, the role of process agents, the process, assessment and strategies; product. Some of them can be found in works related with evaluation process of Project-Based Learning (Lima et al, 2007; van Hattum-Janssen & Mesquita, 2011; Fernandes et al., 2012).

### 3.1 Learning Environment

#### 3.1.1 Characteristics of Projects, Engineering Practices and Workshops

For the respondents the definition given to activities in Projects, Engineering Practices and Workshops was not adequate, with classification criteria that overlapped raising doubts. For one of the interviewees the initial classification indicated that an "Engineering Practice would be a smaller project, lasting up to six months" [FG1P2] and Workshops were related to other activities not directly relevant to engineering knowledge. In the focus group, a consensus was reached on the concept of Projects, Engineering Practices and Workshops.

**Projects** – From an enough common perception, are identified by: having long-term, with periods of up to eight months; be divided into stages; and related to an open and multidisciplinary problem. Open problems are understood as those that allow a variety of ways to solution, or a variety of tools [FG2P4; FG2P3]. They are also associated with the need for a multidisciplinary knowledge, which often are not dominated by students yet.

*In my case, I leave open. The software that the student wants to use. 'You want to use this software. Use it. If you want to use another ... If you want to make an application on the cellphone, do it' "[FG2P1].*

*"... is something bigger, so I need more resources, several knowledge of specific engineering areas, in the case of mine which is control automation ... have to do research, I have to see how it works (the software, the mechanism) ..." [FG2P4].*

The Projects follow a work strategy in stages, which emphasize: organization of work teams; definition of roles of the participants; proposition of the problem; presentation of content by the teacher, which will support the work of the teams; some prior researches on the topic of the problem; search for a solution to the problem; development and testing of prototypes; presentation, oral or written, of results of the work.

**Engineering Practices** - There is no convergence on the characterization of this category. For some, unlike the projects, the Engineering Practices do not have an initial stage of research and development, but a stage in which the teacher presents the content and the problem in a direct way. Related to solution of a problem, but in a **more targeted manner**. For others, the Engineering Practices are identified as **open mini-projects**, only because they have a shorter period for development "with a 'slight' initial research in technical articles" [FG2P3].

*"The student will make the practical implementation of a proposal that is already half set by the teacher. The specific objective is set by the teacher" [FG2P1].*

*"... the student can give his solution, but it's very controlled, that is, with restrictions placed by the teacher and with a specific goal also set by the teacher" [FG2P2].*

It is possible affirm that the Engineering Practices are focused on implementing a process or building a product [FG2P1] in a directed way, without possibility of the student fully utilize their creativity. The goal is to develop engineering skills.

**Workshops** - The aim is essentially lead the student to develop skills in a structure that has a stage of: theoretical presentation by the teacher, of some content; and proposition of a oriented work, to be done. Ends in a single class [FG2P1, FG2P4, FG2P2]; may have a playful character [FG2P2], with the handling of parts, equipment or instruments, to promote skill, in using, installing or building a prototype or, yet, development skills in pencil and paper activities. An example is the workshop 'Mathematics bases', which aims to develop mathematical skills in which the students have difficulty.

*"I think a workshop has ... content to be addressed without ... the intention of creating a product as a project, but generate knowledge of some content" [FG1P2].*

It is possible to conclude that Engineering Practices are associated with the application of an engineering tool without handling many variables, without giving the student the ability to create, as widely as in projects. The Projects are associated with open and multidisciplinary problems, with unknown solution, developed in stages. Workshops, in the other hand, are associated with the development of specific skills, to support the engineering formation and to broaden the horizons of knowledge in technological or scientific aspects.

### 3.1.2 The activities in the context of the 1st year

Some Projects, Engineering Practices and Workshops have a direct link to the subjects of the 1st period, due to the perception that the activities will support the content learned in the subjects. There is also a link with disciplines and contents of higher periods, anticipating the use of them, in the 1st period.

*"In the design of skateboards, at various times ... we deal with materials, and the teacher of materials (following series) helps us. We talk about Physics, Calculus, Materials' Resistance ... We try to show them... because, when the student study this content ... he will do with another perspective, because they realize the actual application" [FG2P2].*

Some Workshops have no link with disciplines. Such is the case of "Negotiation Techniques" which aims are to develop transversal skills, important in the formation of the Engineer.

## 3.2 The process agents

### 3.2.1 Teacher role

According to the participants, the teacher has different roles: advisor, tutor, model, content provider and team coach. One of their functions is to promote the student autonomy, identified as a problem of students arriving to higher education

*"... we need to develop the autonomy of the students, ... every year it is getting more difficult, students have less and less autonomy and, facing the first difficulty, they stop" [FG2P4].*

For each Project a teacher is assigned to act as a team coach, who helps the students in their different roles in the tasks and how they relate, aiming better performance at work. In Engineering Practices, their paper is to be a model, translates into an example of professional skills, to be followed by students. In both the idea is to ensure autonomy to the student.

*"In the project, I think the main role is to assume a position as team advisor. In Engineering Practice is to become a model, as it is very controlled ... you have to show how to do, for him to do the same. In the Project should bring information, help teamwork, and bring all design features, help them to make the schedule ... you have to give them a helping hand, but they have to do (the work themselves)" [FG2P2].*

The teacher's role, as content provider, is to bring the most advanced content necessary for the development of projects, practices and workshops that are not common to the students.

*"I cannot start from premise that they all know how to work with Arduino. So, I give them a basic training in Arduino, focused on programming" [FG2P4].*

In the Workshops the role of teacher is directly associated with a tutor, who conducts a directed study work, respecting the different ripening stages of students.

*"We act as a tutor in the following sense ... There are students who are more autonomous. When he cannot understand something, he asks us. However, there are other students ... who are more passive. They expect you to bring referrals to proceed. What we have done is to give a challenge to the student, in form of a questionnaire, etc., which has a logical evolution ... and, he will answer on..." [FG1P1].*

### 3.2.2 Student role

The teachers have some expectation of students' role as to make choices, decide, conduct practices, research, give solution to problems, all of it associated with having a proactive attitude. The proactivity is an important feature of an engineer's performance, both to identify problems as seek solution. There is a complaint that students arrive to higher education without this profile and should be encouraged to develop it.

*"...I teach: 'Look, that's the way you start the engine.' So he knows that he has to do the little robot walk forward. He starts the engine ... I said: 'Did you know that you could get that engine and another one, connect the two together for the robot go forward?' The student says, 'Oh yeah?' 'You always have to give that little push,' goes a little bit, goes a little goes a bit '. He fails, as was taught by teacher, to join ideas and to do something. We have to develop that autonomy in students ..." [FG2P4].*

About decisions, the argument is that the student does not reach at engineering school prepared for this. Does not realize that a decision, before it is right or wrong, will lead to some consequence: *"This is the role they have to play to become an engineer"* [FG2P1]. Making researches is another assignment of students, whether in Projects or Engineering Practices, research is an element that makes up the process of developing a product or service. Conducting a practical implementation is another assignment of the student, both a proposal from the teacher, such as Workshops or Engineering Practices, and those decided by the student, as in Projects.

## 3.3 The process of assessment

The evaluation of students in Projects, Engineering Practices and Workshops happens in different way. In some Projects and in Engineering Practices students were evaluated for compliance with a set of targets, considering milestones.

*"... They have deadlines. So, at the end of two months, the sensing module have to work properly ... after six months, the communication wireless module has to be working properly and, in the end eight months, to finish, all the artifact and the interface have to be done and working properly" [FG2P1].*

The Table 2 summarizes how the interviewed teachers assess Projects.

Table 2 - Assessment components

Interviewed	Assessment components			
[FG2P1]	Control class attendance	Goal: sensing Programming	Goal: Communication Module	Goal: Prototype Report on the work done
[FG2P2]	Goal: Provide product knowledge - Movies, shows, open.	Project Management Goal: Team Training and role assignments	Specific targets to be met	Target: Report and defence facing "stakeholders"
[FG2P4]	Mechanical design, electronics and software. Reports over the activity.		Goal: Prototype performance in robots Racing	Final report and robot design: electronics, part of the software, mechanics.

Some Engineering Practices and Workshops use the presence in the meetings as a criterion for assessment. As reported by the teacher [FG2P4], who conducts an Engineering Practice, his evaluation just classifies as *"fulfilled or not fulfilled (the activities) ... if the student makes a video, or a sequence of photos, if he makes notes of something ... that's how I'm evaluating"* [FG2P4]. Similarly, for another workshop, the respondent [FG1P1]

reports: "Formally have no evaluation. The students have a work, they will fulfill and we will discuss, we correct on the errors ..." [FG1P1].

### 3.4 Contribution of Projects, Engineering Practices and Workshops - Product

The data analysis showed some main contributions of Projects and Engineering Practices. Materializes the role of the engineer already in the first series; It stimulates responsibility for the acquired knowledge; valorizes the course subjects, both the basic cycle, as the most advanced series; stimulates mature attitudes to assume the attributions of the engineer's work; motivates the student; creates a scenario of freedom allowing to choose their way.

*"Materializes the role of the engineer, already from the first year. ... You do (the student) feel the responsibility and the need for certain knowledge that will be acquired in the first year. Something that when I did (the engineering course), I felt very discouraged because I found engineering in the third, fourth year. Then you already bring in the first trial, the discussion ..."* [FG2P2]

The ripeness of attitudes is translated by involvement with problems: seek solution, seek knowledge, conduct research, make choices, and carry out critical analysis of the situations it faces.

*"He (student) gets out of that context, when he is in high school, in which is always passive and only receives knowledge. Not now. He needs to take a different attitude ... The teacher will not come to him (saying) 'look you will use this tool. Do that way, this, this and this.' You will be directing, but he has freedom to make choices"* [FG2P1].

Explicitly the student's motivation is pointed as the main contribution of Projects, Engineering Practices and Workshops.

*"The engineering course is an extremely dull course in the first two years. You must first motivate. The person has to have a very focused idea ... to endure the first two years of a common course of engineering. In calculus class, the teacher does not always specifies what and when and he will use what he is taught"* [FG2P4].

It is interesting to note that teamwork, although it is considered as differential in work by projects, is indicated just in an isolated speech on the testimony of the respondents, nothing significant.

Workshops are strongly associated with promoting the teaching content and skills, either as subjects of transversal knowledge. They are also associated with the "rescue of high school content that fail on student's knowledge" [FG1P4].

*"In the specific case of the Workshop "mathematical bases", it has a prompt use already in calculus, because we are reviewing a bit before the use in calculus. We are seeing exponential function, logarithmic function, things used in calculus. So there is a direct link"* [FG1P4].

In general, the new curriculum is associated with a scenario of freedom, in which the student can choose the activities they will participate and practice engineering.

*"I think the students saw it the curriculum as being stuck in cast. They had the opportunity to work in that specific area, or something that would give more pleasure to them, only from the third grade on. So now, at first series he already has this possibility to integrate disciplines, (put) really hands-on, and develop complementary topics to what is being seen in theory"* [FG1P3].

### 3.5 Benefits and difficulties

There is a positive outlook on the implementation of Workshops and Projects, but also doubts, sometimes justified by this moment of beginning of changes. The commitment of people is identified as a risk factor, for which just time can promote a better engagement. The speech of the respondent [FG2P1] summarizes some ideas about curriculum reform, shared by other participants:

*"The reform have a lot of positive things. I think it was a big step, and leave a square model ... audacious, for any institution. It is logical, I think we will reap a lot of good, but I think this model will only get good in about five years, at least, when people are already more involved. ... Has a great deal of people involved. Some of them share the ideas proposed, but others do not. I believe that those who do not share the proposal, with time they will getting into rhythm and realizing what is improving. Then, you need to have a great effort to work the team, to have group as a whole, supporting ... 'A gain?' I believe so, because I think the goal of all*



*that is being done is to change the form of teaching engineering. ... Needs to be taught differently, we already have other schools with this view, and engineering [education] needs to get a little more practical, a little less theoretical ... The course has to gain a lot if it can offer the student in a different way [FG2P1].*

The courage in carrying out the reform is shared by other participants in the focus group [FG2P3; FG2P4]. The time for adaptation is another highlight, linked to membership and involvement of teachers to the reform. At the same time there is the indication of the need of group effort, of all teachers to support and sustain the curricular reform, which can be translated into the need for authority and consensus (Powell and Weenk, 2003), to share ideas and reach a working team, to discuss and know results and requirements of new curriculum.

As for infrastructure, respondents showed concern about the adequacy of environments at this beginning. Some activities had a great demand, but a small number of places in classes, hindering meet the demand. This generated the discomfort of having to deny student access to certain activities [FG2P4]. The suggestion is that you create classes and schedules to meet students.

*"My original classroom was U03 and you cannot make a workshop in this classroom. So this is a problem that we will have to think, which the workshops that really need labs are, and what times they must be offered, in such a way as not to overlap classes." [FG1P1]*

The process of choice of activities by students, called "tasting", which is the stage in which students can experience the Workshops, Engineering Practices and Projects, is a disapproving point, because the vast majority of students did not effectively participated and, consequently did not make the choice fully aware of the importance to their training. Participants identify that the choice of students is set by timetable of tasting, title or suggestion from peers and not by the theme or content. Another criticism comes from that the "tasting", happens in just one week, which is a short period, being difficult to students effectively experience all of it and know its value in their training. The high number of activities that the student has to perform throughout the year justifies the option of pursuing the activities in better times, so they can perform all activities.

*"Even the way these workshops and projects were offered; I think we have to change. I do not know if the tasting was a good way, I think we have to check everything" [FG1P4].*

*"The appeal of schedule is much higher than any kind of tasting" [FG1P2].*

*"...I think this problem is also because he is obliged to do many activities. .... Is that it has to do so much ... that will try to set the time, more so than choose.... then need to analyze, think at the end of this year. It was really important to have it done many activities?" [FG2P3].*

Finally, a point raised is the need for evaluation of the work done, so that we can optimize the process, with an eye to the necessary adjustments.

*"Well, at first, it is working. From what we are seeing. Of course I think declare success, or not, will still depend a little bit. We need to reach the end of the year. I think we need to see what will be the condition that these students will reach the second year. Evaluate, compare students we had, the profile of the student we had with the student who will come to us next year. I think all this will require a good evaluation, honest, to maybe even make an assessment to verify 'let's back up a little'. We will need to fix a little here and there" [FG1P1].*

## 4 Final Remarks

The aim of this work is to analyze the motivation and expectations of teachers involved in the transformation of an "ideal curriculum" into a "formal curriculum". They are responsible for Projects, Workshops and Engineering Practices offered to students of the first period of an engineering school, which is promoting a curricular change to PBL. Many benefits in student's learning were reported such as responsibility by acquired knowledge, appreciation of course subjects, mature attitudes and a scenario of freedom allowing students to choose their way in the course. Similarly, teachers assume their role differently, confirming the readiness to work with these strategies. There is a non-convergent view on various aspects of the Projects, Engineering Practices and Workshops, generating doubts and uncertainties about the strategies used in these activities and in the evaluation process. These differences may be a factor that implies a lower efficiency to ensure maturation of the teaching staff and ripening of these activities. That is, the time to reach an optimum level with the curriculum reform can be extended, and thus generate a climate of dissatisfaction and even discouragement

of participants. In this sense, the attention of the management team is crucial to support work development, as revealed by the participants of the focus groups.

In general, there is a perception that the work is being done but there is much to be improved. It is possible to notice the commitment of teachers who put their creativity and talent making changes, seeking the success of the proposal, although there has been a critical skepticism, prompting careful evaluation to be know if the results are actually positive. Sharing knowledge about the PBL characteristics is something that deserves attention, which is evident from the fact that interdisciplinary has not been used in the activities, as noted in previous interviews reported by Mattasoglio, Lima and Mesquita (2015), which could enhance the performance of work, aligning it with the definition of Problem Project (Kolmos, 1996). It is possible to realize that the context has some conditions that need alignment to guarantee a better performance of curricular change. As an example, there is the need to improve the suitability of classrooms and timetables, to attend the students. Further, the process of assessment and a better organization of strategies claim for change too.

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